



ENHANCEMENT OF SAFETY BARRIERS IN A MAGNETIC RESONANCE UNIT: A Brazilian Experience

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Introduction

Magnetic resonance imaging (MRI) is the result of the interaction of a **strong magnetic field** with hydrogen protons within the patient's body...

...which create a situation where a **radiofrequency pulse (RF)** is applied through RF coils.

The **signal emission** is provided by the hydrogen protons, and then collected, processed and converted into **images**.

! Under normal conditions of use of the MRI device, the magnetic field **never** turns off!

MRI components that can be related to **adverse effects** on patients:

RADIOFREQUENCY

GRADIENTS

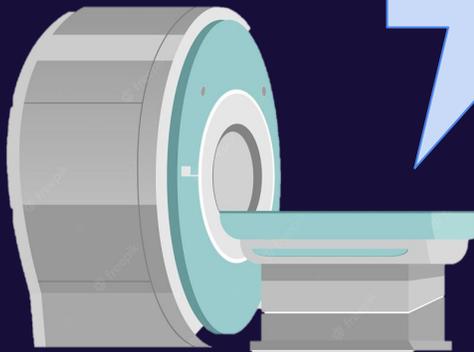
CRYOGENIC

MAGNETIC FIELD

CONTRAST AGENTS



Main adverse effects related to the magnetic field: attraction/twisting ferromagnetic objects; changes in the functioning of non-compatible electronic devices; tissue burnings, etc.



Source: Haik et al



Source: Mailonline

Introduction

Adverse events related to the magnetic field have been described worldwide:

In 2008, 148 reports were submitted

Pennsylvania Patient Safety Advisory

Safety in the MR Environment: MR Safety Screening Practices

1568 adverse events reported between Jan/2008 and Dec/ 2017.

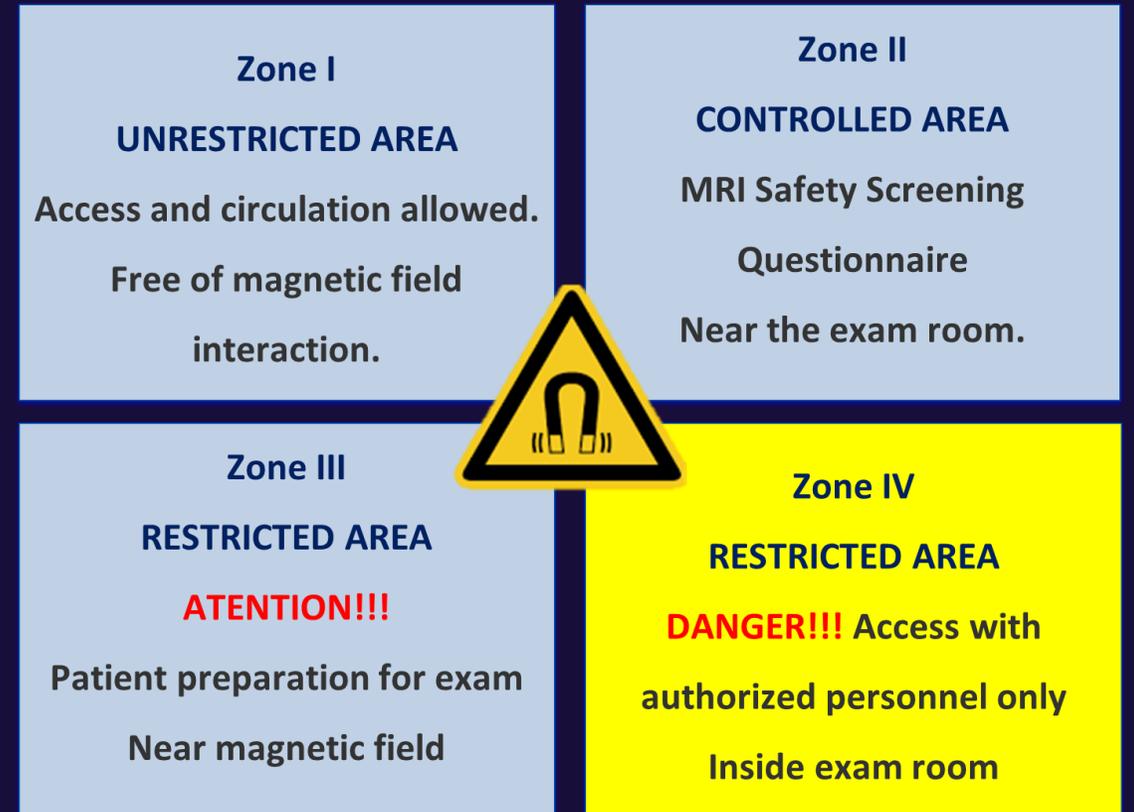
MRI-related FDA adverse event reports: A 10-yr review

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Some adverse events have also taken place at our institution in the recent years.

Aiming to prevent these events, the American College of Radiology has defined four **safety zones** within MRI facilities:



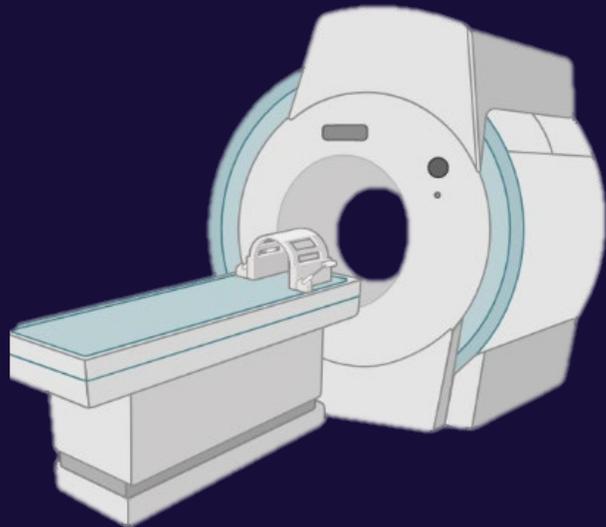


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Objectives

To describe our institutional experience in optimizing safety barriers in a MRI unit of a Brazilian private hospital (8 MRI machines).



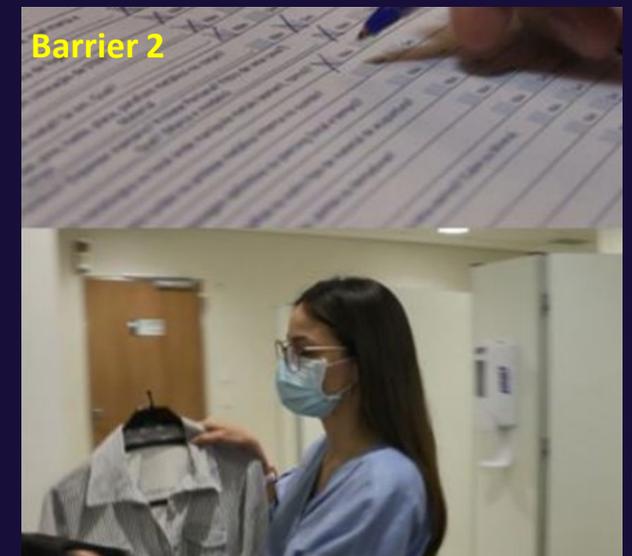
To discuss the importance and the feasibility of the educational and security initiatives in order to prevent accidents and to provide a better experience for patients and healthcare professionals.



Methods

This project was developed from September 2019 to September 2021. The following security barriers were implemented:

- **Barrier 1** - The scheduling team asks a series of standardized questions to ensure that the patient have no contraindications to the MR scan.
- **Barrier 2** - The patients is oriented to fill a security questionnaire, to change clothes and to remove disposable metallic belongings (zone I).



Methods

- **Barrier 3** - A first professional check all the patient's answers in the safety questionnaire (zone II). Some answers can require personalized investigation.
- **Barrier 4** - A second professional recheck the identification data and the safety questionnaire before entering the examination room with the patient (zone III).



Source: Sírio Libanês Hospital

Hospital
SírioLibanês
SOCIEDADE BENEFICENTE DE SENHORAS

Pre-Exam Questionnaire

Accounting: _____ Same: _____
 Patient: **M.P.S** Age: **35**
 Date of hospitalization: **10/07/222** Bed: _____
 Physician: _____

Magnetic Resonance Imaging

Attention, please: your answers are extremely important for the performance of the test.

Weight **65** Kg

1. Do you use a pacemaker?	<input checked="" type="checkbox"/> No	<input type="checkbox"/> Yes
2. Have you ever been submitted to clip or cerebral valve placement?	<input checked="" type="checkbox"/> No	<input type="checkbox"/> Yes
3. Have you ever undergone aneurism surgery?	<input checked="" type="checkbox"/> No	<input type="checkbox"/> Yes
4. Have you ever had a wound caused by metal chip or firearm?	<input checked="" type="checkbox"/> No	<input type="checkbox"/> Yes
5. Have you ever undergone heart surgery or stent placement?	<input checked="" type="checkbox"/> No	<input type="checkbox"/> Yes
6. Do you have a Port-A-Cath catheter (totally implantable)?	<input checked="" type="checkbox"/> No	<input type="checkbox"/> Yes
7. Do you have prostheses, clips, pins, stems, plates, or metallic screws in the body?	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes
8. Do you work in metallurgy or a place where metal is handled (grinder, lathe)?	<input checked="" type="checkbox"/> No	<input type="checkbox"/> Yes
9. Do you wear a hearing aid or inner metallic aid in the ear?	<input checked="" type="checkbox"/> No	<input type="checkbox"/> Yes
10. Do you have tattoo, definite makeup or piercing (site and time)?	<input checked="" type="checkbox"/> No	<input type="checkbox"/> Yes
11. Do you have points, needles or any other type of acupuncture material?	<input checked="" type="checkbox"/> No	<input type="checkbox"/> Yes
12. Do you have dental braces, bridges or dental prosthesis?	<input checked="" type="checkbox"/> No	<input type="checkbox"/> Yes
13. To women: are you pregnant?	<input checked="" type="checkbox"/> No	<input type="checkbox"/> Yes
14. Have you undergone any recent surgery that implanted metals?	<input checked="" type="checkbox"/> No	<input type="checkbox"/> Yes
15. Are you wearing contact lenses or common makeup?	<input checked="" type="checkbox"/> No	<input type="checkbox"/> Yes
16. Do you have any renal disease or any grade of renal failure?	<input checked="" type="checkbox"/> No	<input type="checkbox"/> Yes

Previous exams maintained in the hospital

Exam **No exam** Origin _____

I am aware of the importance of this questionnaire and authorize the performance of the exam

Signature of the Patient / responsible person
M.P.S

E_0116_Pre-Exam-Questionnaire_Magnetic-Resonance-Imaging - 11/2007

The safety questionnaire is an important barrier to identify risk factors to adverse events and MR contraindications. In this case, the pointed answer must be further investigated.

Security Questionnaire



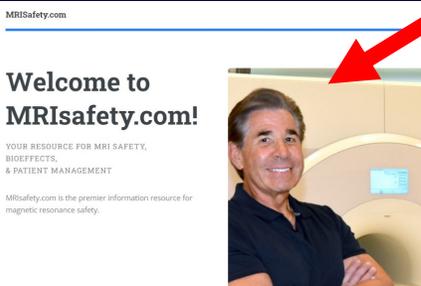
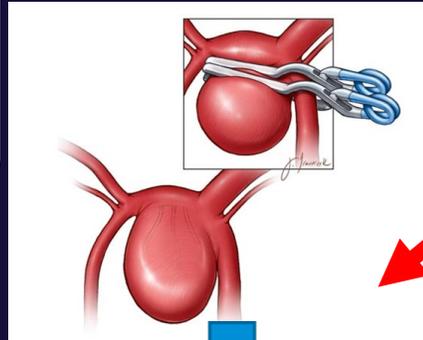
Methods

Internal Improvement Standards

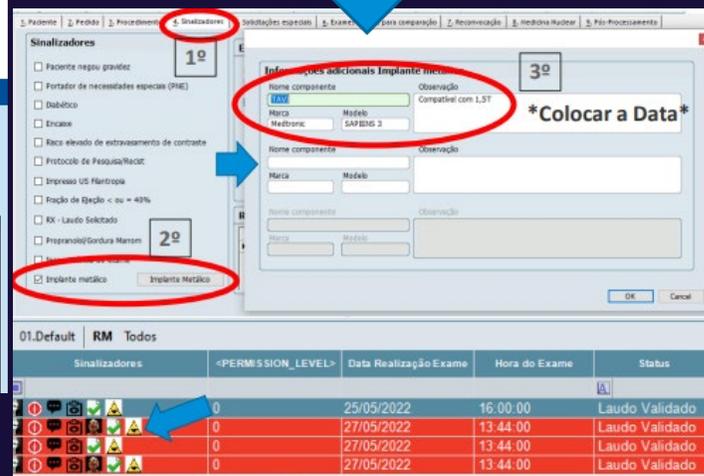
The investigation of the compatibility of materials and devices was carried out by consulting the **MRI safety website**.

The **patient registration system** was fed with data related to MRI safety, such as the size of implants and devices.

Whenever necessary, **additional security measures** were taken in our service, such as the installation of a security camera at MR waiting room after an wheelchair accident.



<https://www.mrisafety.com>



Region: Abdomen

SECURITY IN MAGNETIC RESSONANCE:

The following table is divided in body regions that subdivides in device types. Each item has manufacturers and models previously researched. The columns present the conditions according to the following classifications: Safe, Safe but with restrictions to 1.5T, Compatible but with other restrictions (described in "observations"), Safe for conscious patients and Unsafe (non-compatible)

Region	Device	Manufacturer/Model	Compatibility	Observations	Source
Abdomen	Aortic Metallic Valve	St Jude Medical	Compatible but with restrictions (conditional)	"MECHANICAL HEART VALVES TISSUE VALVE ANNULOPLASTY RING Patients can be safely scanned, immediately after implantation, under the following conditions: 1) Static magnetic field of 1.5 Tesla (1.5T) or 3.0 Tesla (3.0T). 2) Maximum spatial gradient field less than or equal to 3,000 Gauss/cm (30 T/m). 3) Normal Operating Mode: Maximum whole-body averaged specific absorption rate (SAR) of 2.0 W/kg for 15 minutes of scanning in Normal Operating Mode at 1.5T. 2.0 W/kg for 15 minutes of scanning in Normal Operating Mode at 3.0T."	
Abdomen	Aortic Valve	Corevalve	Compatible but with restrictions (conditional)	"2.3 MRI Information: Nonclinical testing and modeling has demonstrated that the bioprostheses is magnetic resonance (MR) Conditional. It can be scanned safely under the following conditions: • Static magnetic field of 1.5 Tesla and 3 Tesla • Spatial gradient field of 25,500 Gauss/cm • Normal operating mode only with a maximum whole body specific absorption rate (SAR) of 2.0 W/kg for 15 minutes as read from equipment indicator 6.2.1.1.1. • Tests Based on nonclinical testing and modeling, a 20 mm bioprosthesis was calculated to produce a temperature rise of less than 3.5°C at a maximum whole body averaged SAR of 2.0 W/kg for 15 minutes of MR scanning in a 64 MHz whole body transmit coil, which corresponds to a static field of 1.5 Tesla. 6.2.2.5 Tests Based on nonclinical testing and modeling, a 30 mm bioprosthesis was calculated to produce a temperature rise of less than 3.6°C at a maximum whole body averaged SAR of 2.0 W/kg for 15 minutes of MR scanning in a 128 MHz whole body transmit coil, which corresponds to a static field of 3 Tesla. 2. Testing conducted in a 1.5 Tesla General Electric Signa RF coil with model number 46-23817001. 3 These calculations do not take into consideration the cooling effects of perfusion and blood flow. The maximum whole body averaged specific absorption rate (SAR) was derived by calculation and verified by calorimetry. Testing conducted at 3 Tesla (128 MHz) employed a 1.0 Tesla General Electric Signa HDx 3.0 MR system with Software Version 15LXMR Software release 15.0.MA.0910 on 16.6.2.3.1.5 Tesla and 3 Tesla The bioprostheses should not move or migrate when exposed to MR scanning immediately after implantation. MRI at 3 Tesla and 1.5 Tesla may be performed immediately following the implantation of the bioprosthesis. The magnetic force	



Methods



Adverse events were recorded in our incident notification system (INS), available in our institution's internal platform.

A educational training was carried out annually, first for all employees in the radiology department and then for other care professionals who could have indirect (such as the cleaning team) or intermittent (such as transport team) contact with the MRI unit.

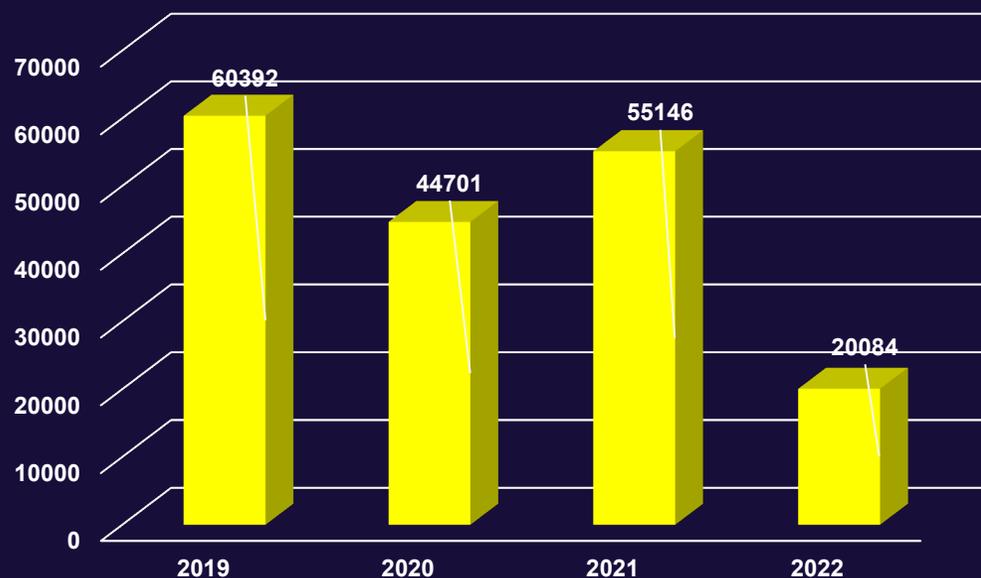
The screenshots illustrate the 'Webtickets' system interface for incident reporting. The top section shows the login page with a red box highlighting the 'Registro de Ocorrências' header. The middle section shows the '01. Notificação de ocorrências assistenciais' form, which includes fields for 'Autor', 'Data', 'Ocorrência', and 'Descrição'. The bottom section shows a menu with '01. Notificação de ocorrências assistenciais' highlighted in a red box.

Data was collected through the INS, and we were able to compare the data related to the events that occurred **before and after** the implementation of our security project and educational training.

Results

The impact of our interventions was evaluated by the number of adverse events recorded in our incident notification system, **before** and **after** the described safety barriers and educational training program.

Number of MRI scans per year



Number of occurrences by MRI Security Failure





Take home message

References

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Safety in the MR environment is a institutional duty!

Each institution should elaborate its own security and education plan (following international guidelines) in order to prevent adverse events and to provide a better experience for patients and healthcare professionals.

